EFFECT OF VEGETATION MANIPULATION ON WATERSHED PROCESSES AND FUNCTION -PAIRED WATERSHED STUDY IN THE UPPER WEBER RIVER BASIN

Final Report
04-DG-11222032-033

Final Report, Coop Agreement 32-033 between USFS, Rocky Mtn. Research Station and Utah State University, College of Natural Resources

Effect of Vegetation Manipulation on Watershed Processes and Function – Paired Watershed Study in the Upper Weber River Basin

[2005]

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Introduction and Justification

The Coop Agreement 32-033 between USFS, Rocky Mtn. Research Station and Utah State University, College of Natural Resources was designed to provide monies for purchase and installation of instruments necessary for assessing water yield as affected by vegetation manipulation. These monies were part of a larger pool that was obtained from several sources with the objective of funding a large interdisciplinary research effort to assess the effects of vegetation manipulation on various resources. The following summarizes the first year of this interdisciplinary effort. Specific reference to the use of monies from the Coop Agreement 32-033 are contained below on page 8, under "Work Accomplished in Year 1"

Prolonged drought in the Intermountain West has led to renewed interest in vegetation manipulation/restoration in wild land watersheds for the purpose of increasing water yields. Manipulation and restoration have the potential to induce many physical, geochemical, and biological responses that, in turn, could dramatically alter watershed function. To better understand watershed level responses to vegetation manipulation and to help provide the necessary scientific basis for future large-scale manipulations, we are conducting an integrated watershed research project that looks at the interaction among vegetation, soil processes, and hydrology as the framework for assessing change and for evaluating the balance between potential benefits (potential increase in water yield) vs ecological costs (productive capacity, ecosystem function, water quality) associated with watershed vegetation manipulation.

Our research is focusing on conifer and aspen communities of northern Utah. Past research suggests that the extent of aspen communities has declined 50-60 % since European inhabitation in Utah, and encroachment by conifers has been a significant factor in this decline. Concomitant with this decline has been significant changes in many natural resources including, it has been hypothesized, watershed water yield. Our research is focused on conifer encroachment into persistent quaking aspen (*Populus tremuloides*) stands and the consequential effects on watershed water yield and other natural resources. Our research will assess the effects of manipulations involving the removal of encroaching conifers and restoration of healthy aspen communities. This core research will take a paired watershed approach, and is predicated on full funding over five years. The two research watersheds, Bear and Frost are located in the upper Weber River drainage and are entirely within lands owned by Deseret Land and Livestock property. Essential complementary research will be conducted as additional funding is secured. The overall research program involves a partnership of public and private stakeholders and a research team headed by USU scientists. Primary funding of this work is being provided by the USDA Natural Resources Conservation Service, Utah Agricultural Experiment Station, Utah State University College of Natural Resources, USFS Rocky Mountain Research Station, Utah Department of Natural Resources, and Utah Department of Food and Agriculture.

Core Research Effort

Water and Watershed. Water links atmosphere, soil, vegetation and streams in semi-arid ecosystems. It plays a critical role in vegetation distribution and composition; in ecosystem productivity and carbon accumulation; as well as in the cycling, availability, and movements of nutrients from the terrestrial to the aquatic part of the watershed. Hydrology also underpins

many of the biogeochemical, geomorphic and ecosystem functions within watersheds as a substrate in chemical reactions and a delivery mechanism, controlling translation of upslope process signals to streams. Understanding watershed hydrologic function, connection between watershed reservoirs of water (soil moisture, groundwater, snowpack, etc.), and water residence times are therefore central to our research.

Vegetation Related Research. Vegetation manipulation and ensuing changes in physiological and structural characteristics associated with community may have a drastic impact on water, carbon and nutrient cycling. Vegetation communities may differ in their water use patterns, resulting in a differential effect on watershed water balance, and hence water yield. A thorough understanding of pre-and post- manipulation vegetation structure and concomitant ecosystem water use patterns is therefore necessary to be able to predict the magnitude and longevity of potential water yield gains.

Soil and Soil Carbon Research. Vegetation further influences accumulation and cycling of carbon and nutrients: directly, as a key component in the growth-uptake-litterfall-decomposition cycle; and indirectly, through its effects on soil microclimate, which in turn influences soil biogeochemical processes. The soil is a major repository of ecosystem carbon (C). It represents the balance between C inputs from plants and losses from the soil with water (leaching) or through microbial decay (CO_2 loss to atmosphere), and the climatic factors that control these processes. Soil organic carbon (SOC) is considered an integral part of site productive capacity, and the amount, distribution, and quality of this SOC also governs the transformation, retention, and availability of many essential nutrients (e.g., nitrogen, phosphorus) by influencing microbial and physico-chemical processes taking place in the soil. To date, there is a lack of reliable estimates of soil C for major vegetation types in Utah, and only a limited understanding of soil C dynamics in semi-arid montane ecosystems under current conditions, following major disturbances (e.g., fire, vegetation manipulation), or as under predicted future climate change scenarios. Our research is intended to address several questions with regards to belowground soil processes such as: How big are the SOC pools under forest and rangeland ecosystems typical of Utah? What are the differences in quantity, distribution, quality and stability of SOC among the ecosystems? How does SOC quantity and quality affect N and P dynamics in the soil? What is the effect of soil biogeochemical processes on water quality? What are the short- and long-term effects of vegetation manipulations of ecosystem C stores, nutrient availability, and water quality? In addition to assessing changes in water yield in response to vegetation manipulation, we believe our research will also make a significant contribution in providing baseline information for future initiatives on C sequestration and C storage credits.

Additional Research Efforts. It is well understood that this core research effort will only address water relations and some biogeochemical questions and that complementary research is a very desirable addition to this work. In this light, we will attempt to expand the scope of this research to include additional essential topics related to vegetation manipulation. These additional research topics will involve additional cooperators and additional outside funds, but the effort will be coordinated under this core research effort.

Research Approach

This project has wide ranging implications for forest and watershed management and has attracted much interest outside the immediate research realm. While the core research will be coordinated by the three principal investigators (Ron Ryel, Mike Gooseff, Helga van Miegroet), a partnership of interested stakeholders has been developed and meets regularly to provide input to the research program. In addition, an extended team of researchers at USU has been meeting to coordinate additional research efforts.

The core research will entail an experiment investigating the impact of vegetation manipulations on watershed processes and function, using a paired watershed approach in combination with directed field studies and numeric modeling. The project will be conducted in three consecutive phases.

Attempts are being made to secure funding for essential additional research related to these manipulations. This includes research related to restoration and maintenance of healthy aspen communities, and the effects on additional resources, including wildlife, forage availability, riparian vegetation, aquatic biota and geomorphology. The development of a sociological and economic research component is also desired.

Stakeholder Partnership

A partnership of interested stakeholders was established at the start of this project, and is called the Utah Sustainable Ecosystem Restoration Program (USERP). This group includes 15 members from various state, federal, and private groups (Table 1) interested in forest management and watershed health. The purpose of this group is to both to provide input and perspective, and to keep these interested parties up to date with the research program and findings. The group meets on a bi-monthly basis at USU or at Deseret Ranch to discuss research ideas, logistical issues, program progress and potential for additional funding for expanding the project.

Table 1. List of partners participating in discussions on vegetation manipulation in Utah.

Name	**Title**	**Organization**	**Email Address**
Bartos, Dale	Project Leader	USFS, Rocky Mtn. Research Station	dbartos@fs.fed.us
Christy, Kim	Assistant Director	Utah School & Institutional Trust Lands	kimchristy@utah.gov
Condrat, Charles	Forest Hydrologist	USFS, Wasatch-Cache NF, SLC	ccondrat@fs.fed.us
Frandsen, Joel	State Forester	Utah Dept. Natural Resources	joelfrandsen@utah.gov
Green, Shane	Range Management Specialist	USDA/NRCS	shane.green@ut.usda.gov
Hawkes, Tim		Trout Unlimited	thawkes@tu.org
Hopkin, Bill	Manager	Deseret Land and Livestock	bhopkin@fmc-slc.com
Jacobson, Jake	Administrative Officer	Utah Dept. Agriculture and Food	JakeJacobson@utah.gov
Julander, Randy	Utah Coordinator	Snotel, NRCS, USDA	randy.julander@ut.usda.gov
Lowe, Mike	State Geologist	Utah Geological Survey	mikelowe@utah.gov
Paxman, Scott	Assistant General Manager	Weber Basin Water Conserv. District	spaxman@weberbasin.com
Petersen, Mark	Director of Water Quality Programs	Utah Farm Bureau	mmpetersen@fbfs.com
Ryel, Ron	Assistant Professor	USU: Forest, Range, Wildlife Sciences	ron.ryel@usu.edu
Teichert, Burke	General Manager	Deseret Land and Livestock	bteichert@fmc-slc.com

Research team

Vegetation manipulation affects landscape level processes, and to effectively conduct research into the broad implications of these manipulation requires researchers with varied backgrounds. The core research effort is coordinated among three principal investigators, but additional researchers are involved in planning the manipulation and other essential research efforts that link to this work (Table 2). Various researchers meet concerning the research and manipulation issues when necessary to coordinate efforts. The three primary groups of focused research interest are (1) a group focused on Landscape Assessment, (2) a group focusing on aspen ecology and genetics, and (3) a group focused on soil biogeochemistry. These research groups allow for the development of research programs that will dovetail with the core research part of the program. These groups have been successful in obtaining additional funding for essential related research, and will continue to seek additional funding for expanding the research effort.

Table 2. Utah State University faculty who are involved in the aspen/conifer water yield vegetation manipulation/restoration research effort.

Name	Specialty	Department, College	Email Address
Baker, Fred	forest pathology, computer applications	FRWS, CNR	forpest@cc.usu.edu
Baker, Michelle	ecosystem ecology	BIOL, CS	michelle.baker@usu.edu
Boettinger, Janis	pedology, soil genesis	PSB, CA	jlboett@cc.usu.edu
Brunson, Mark	environmental attitudes and policy	ENVS, CNR	brunsonm@cc.usu.edu
Chandler, David	hillslope hydrology, erosion	PSB, CA	dchandle@mendel.usu.edu
Edwards, Tom	Wildlife, monitoring	FRWS, CNR	tce@nr.usu.edu
Gooseff, Michael	watershed and isotope hydrology, biogeochemistry	AWER, CNR	michael.gooseff@usu.edu
Long, Jim	Forest Ecology, Silviculture	FRWS,CNR	fakpb@cc.usu.edu
Malechek, John	Range and forest ecology, veg. manipulation	FRWS, CNR	john.malechek@usu.edu
Mock, Karen	genetics	FRWS, CNR	karen.mock@usu.edu
Pfrender, Mike	genetics	BIOL, CS	pfrender@biology.usu.edu
Provenza, Fred	range animal production	FRWS, CNR	stan@cc.usu.edu
Ryel, Ron	plant ecophysiology, systems ecology	FRWS, CNR	ron.ryel@usu.edu
Shultz, Leila	plant taxonomy and geography	FRWS, CNR	shultz@cnr.usu.edu
VanMiegroet, Helga	forest soils, biogeochemistry	FRWS, CNR	helgavm@cc.usu.edu

CNR = College of Natural Resources; CA = College of Agriculture; CS = College of Science

Core Research Effort Funded by this Project

The core research effort involved three phases directly linked to the schedule of a sizable vegetation manipulation within one of the paired study watersheds.

- **Phase I.** Characterization of the watershed components: What is there?
- **Phase II.** Dynamic connections between vegetation, soils and water: How are the pieces connected? How are terrestrial properties and processes translated into water quantity and quality?
- **Phase III.** Watershed response to vegetation manipulation: How does watershed function change following manipulation?

Phase I. (2 years)

The initial phase of the research program involves a thorough characterization of the watersheds and the communities within them (i.e., conifer forest, aspen forest, sagebrush steppe). This would include (but is not limited to):

Characterization of the plant communities and ecosystems. The structural composition of conifer and aspen plant communities is being characterized. This includes an inventory of understory vegetation and invasive weeds. Consumption of vegetation by wildlife and livestock will be estimated in these plant communities. We are also quantifying the water use patterns of conifer and aspen vegetation communities to evaluate their effects on the watershed water balance. This includes assessing the timing of water use using sap flow instrumentation and depths that water is accessed using deuterium O^{18} composition of water taken up by plants.

Characterization of soil nutrient pools and their dynamics. As part of this activity we are conducting a background soil survey with representative soil pedon description in the different ecosystems. We are also characterizing the amount, distribution and quality of SOC in the different parts of the watershed to elucidate its role in the cycling of other nutrients, its relative stability, and its sensitivity to watershed manipulations. This is being done through a combination of field sampling, laboratory assays, and fractionation techniques. We are also characterizing N and P pools and dynamics in these soils, and towards the end of Phase I, we will investigate possible feedbacks between N and P behavior and vegetation composition, SOC characteristics and soil microclimate

Characterization of hydrology. This is being done by sampling meteorological parameters (precipitation, temperature, solar radiation, relative humidity), soil moisture distribution, stream flow, isotopic characteristics of precipitation, soil water and stream water, and chemical characteristics of precipitation, soil water, and stream water. Spatial and temporal patterns of precipitation, soil, and stream water chemical constituents and water isotopes (deuterium and ^{18}O) are being used to determine hydrologic flowpaths and residence time distributions.

During this phase of the research we have installed instruments and equipment for monitoring site climate (weather stations), soil temperature and moisture regimes in the different components of the watershed (temperature probes and soil tensiometers), and collecting soil water (tensiometers), stream samples (stream gauge and automatic samplers) and plant transpiration rates.

Phase II. (1 year)

The objective of Phase II is to establish the connection between vegetation, soil and hydrology and start characterizing watershed function in those terms. This will be done by building on the initial data collected in Phase I. Specifically we will explore hydrologic pathways by conducting hillslope, riparian, and stream tracer experiments, establish which areas of watershed are hydrologically and biogeochemically active, how activity changes over time,

and investigate the role of water in translating terrestrial processes into an aquatic response. Furthermore, we will focus on N and P as potential water pollutants, and investigate what controls their form and movement from the watershed into the streams. Using water chemistry already collected in combination with natural tracer studies we will explore which areas are contributing water and/or nutrients to the stream. Only when we fully understand how the watershed functions under natural unperturbed conditions, can we begin to investigate the potential effects of vegetation manipulation.

Phase III. (2 years)

Vegetation manipulation should not commence until we have sufficient and high-quality baseline hydrological and hydrochemical data. We propose that such data should be collected for a minimum of 3 years prior to watershed treatment. Therefore, it is anticipated that treatment implementation and post-treatment data collection will only commence at the end of the 3- to 3.5-year planning period. The 5th year of the project will be the start of post-treatment assessment with continued collection of meteorological, hydrological and transpiration data, and repeat sampling and monitoring of specific plots investigated in pre-treatment work.

Additional Research Efforts

Presently, the research efforts supplementing the core research effort can be divided into three efforts. Additional efforts involving other resources affected by vegetation manipulation will hopefully be developed in the near future as funding is secured. These include: wildlife habitat, riparian vegetation dynamics, within stream biota, stream geomorphology, groundwater hydrology, and socio-economic issues.

Landscape Assessment within forest lands. This research is designed to better understand ecological classification and management of forest lands. To be effective, vegetation manipulation in forest lands must be conducted in appropriate areas with appropriate and effective outcomes expected. Specifically to the core project, manipulations to restore healthy aspen communities have to be done in landscape locations where aspen communities fit on the landscape, and where sustainability is possible. This research focus is to be conducted primarily within Franklin Basin in Cache County, with the paired watersheds of the core research project also included in the scope of this work. The goals of this effort are: 1) characterization of current and reference conditions for major landscape components; 2) identification of opportunities and challenges for restoration; 3) identification of potentially critical information gaps; and 4) specification of focused research projects needed to drive adaptive management.

Aspen Ecology and Genetics. Restoration and subsequent maintenance of healthy aspen communities is a primary outcome of vegetation manipulation involved in the core research area. Aspen is a clonal species and clones seem to be persistent on the landscape in many ecological settings in northern Utah. However, this species seems to have very limited ability to become reestablished through seeds. The aspen research group is designed to 1) conduct a comprehensive review of the aspen literature, 2) assess the health of aspen in Utah, 3) understand the link between aspen sustainability and conifer encroachment, 4) assess the importance of genetic variability of this clonal species on the landscape, 5) assess the importance and management

implications of differences in phytochemistry to aspen establishment and persistence, and 6) develop effective guidelines for maintenance of healthy aspen communities. This research effort involves both new funding and linking to the existing Cedar Mountain Initiative, coordinated by Rocky Mountain Research Station and USU researchers.

Soil Biogeochemistry. Vegetation manipulation where plant communities are replaced by others may have profound effects on soil moisture, carbon and nutrient dynamics. This effort is focusing on soil differences in soil carbon pools and dynamics among forest communities. The amount of soil organic carbon (SOC) depends upon the balance between carbon input to and carbon loss from the soil. The quantity of carbon input to the soil depends on the type and productivity of vegetation in the ecosystem, which influences carbon allocation into aboveground vs. belowground plant biomass and quality. The carbon export from soil occurs (1) as CO_2 losses from microbial decay, which depends on the decomposability of SOC; and (2) via leaching of dissolved organic carbon (DOC), which depends on the solubility of SOC and actual hydrologic fluxes. Vegetation can influence SOC loss (or inversely C retention)) by influencing both substrate quality and/or soil microclimate. In northern Utah, where most precipitation falls as snow in winter, the soil moisture regime is closely linked to snow dynamics. Spatial and temporal variability in soil moisture affect belowground C dynamics by altering biological activity and leaching potential. Global climate change is likely to influence C cycling by changing site hydrology, soil temperature regime, and soil moisture availability.

Work Accomplished in Year 1

The following is a summary of work conducted with the core resources of this project. These were funded by the core research monies except where noted.

- Purchase of stream flow gauges, weather stations, and daily water quality sampling equipment (funding for equipment from Utah DNR, Utah Food and Ag., Rocky Mtn. Research Station, USU-CNR).
- Installation of stream flow gauges in Bear and Frost Canyons in winter 2003-04 (some funding from Utah DNR, Utah Food and Ag., Rocky Mtn. Research Station, USU-CNR).
- Continuous monitoring of flows from Bear and Frost Canyons (some gaps).
- Installation of daily water quality sampling instrumentation in winter 2003-04.
- Collection and analysis of daily water quality samples (some gaps, especially in winter).
- Installation of two weather stations in winter 2003-04 – top of Bear Canyon, and the confluence of Bear and Frost creeks (some funding from Utah DNR, Utah Food and Ag., Rocky Mtn. Research Station, McIntire Stennis funds).
- Collection of continuous weather data from these two stations (some gaps).
- Preliminary field experiment to investigate stream flow generation in relation to landscape features.
- Installation of a SNOTEL station in upper Frost Canyon in summer 2004 (other NRCS funding).
- Monitoring of snow pack data from the SNOTEL station (other NRCS funding).
- A network of soil moisture sensor stacks to continuously monitor soil moisture was designed to coordinate with the SNOTEL site and with the core research effort (installation delayed until spring 2005, funding in part from other NRCS funding).

- Funding of one graduate student (Brooke Shakespeare) to conduct research on flows and water quality.
- Purchase 4x4 truck, 2 snowmobiles, 2 ATV's for field use. Two additional field trucks were obtained (Gooseff, and Ryel) from other funds.
- Develop web site (http://www.cnr.usu.edu/userp/) for core research program with links to associated research efforts.
- Develop on-line literature database of research linked to vegetation manipulation and effects on resources (accessed through http://www.cnr.usu.edu/userp/).
- Purchase initial sap flow equipment for monitoring water use by aspen and conifers.
- An experimental design was developed for assessing three hypotheses for differences in water yield between conifer and aspen. The hypotheses were: 1) differences in snow accumulation and/or melting pattern, 2) bare soil at base of conifer trees during later winter provide sink for water that is evaporated or transpired (similar wells do not occur with aspen), and 3) differences in pattern of water use and total water use due to differences in physiology between conifers (evergreen) and aspen (deciduous).
- An inventory of the current riparian community vegetation in the Bear Creek and Frost Creek drainages within the study area was conducted. Existing range conditions, percent cover and species composition were quantified.
- A threatened, endangered and forest sensitive plant inventory and a noxious weed inventory were conducted along both drainages and along most of the roadways leading into Bear and Frost Creek drainages.
- Frost and Bear Creeks were inventoried using Single Ocular Estimates (SOEs) as defined by the Level II methods (USDA FS 1992). Each stream was divided into separate reaches based upon the riparian complex identified in the field (Rosgen classification), with digital photos taken of upstream and downstream diagnostic features at the beginning of each new reach. Valley bottom, gradient and valley side slopes were assigned to each reach.
- Funding of one graduate student (Eric LaMalfa) to conduct review of research on water yield as related to vegetation manipulation.
- Funding of one graduate student (Leanna Ballard) to begin review of ecological site classification for aspen and conifers in northern Utah.
- Funding of one graduate student (Paul Rogers) to review aspen health in northern Utah and link this to land management (first year of funding from outside project).
- An extensive literature database on aspen has been compiled (7,000 references) and will eventually be placed on-line (funding through Rocky Mtn. Research Station).
- Funding of one postdoc (Sam St. Clair) during summer 2004 to assess physiological differences among aspen clones and to collect aspen leaves for genetic analysis to be related to ecological setting (aspect, ridgetop, valleybottom). A manuscript is in development from this work.
- Collect aspen leaves from a sampling matrix in Swan Flats to determine aspen clone size and genetic interrelationships among clones (funded in part from other projects).
- Collect aspen leaves for genetic analysis to assess linkage to phytochemical expression that affect utilization of aspen by elk and livestock (funding from Rocky Mt. Research Station).

- Compile to one source all GIS and Remote Sensing data that includes Deseret Ranch and surrounding area (funding from Wasatch-Cache NF).
- A pilot study was conducted to assess methods for investigation soil carbon in different plant communities. A total of 36 5 x 5 m plots were laid out in Sunset Ridge to the West of Doc's Meadow in the T.W. Daniel Experimental Forest in a randomized block design with three blocks and three treatments (control, additional summer precipitation, accelerated winter snowmelt) in four vegetation types (aspen [Populus tremuloides] and conifer mixture of fir [Abies lasiocarpa] and spruce [Picea engelmannii]; sagebrush steppe [Artemisia tridentata] and grass-forb meadow).
- Installation of instruments in all control and irrigation plots (24 plots total) including TDR's measuring soil moisture at 0-25cm and 25-50 cm soil depth, tensiometers at 10 and 50 cm soil depth (soil water tension), tension lysimeters at 10 and 50 cm (soil solution chemistry), mini temperature data loggers (Onset Tidbits) were installed at 15 cm soil depth in all plots in summer and will be downloaded annually.
- First irrigation immediately after plot installation and instrumentation in August, 2004 and measurements of soil respiration were taken in control and irrigated plots in summer-fall 2004 using the static chamber technique with NaOH as a trapping agent.
- Developed proposal to the US EPA Watershed Initiative program entitled: Improved Watershed Function Through Ecosystem Restoration—The Deseret Ranch Demonstration Project, Eastern Weber County, Northern Utah. Principals for this proposed work were Ron Ryel, Mike Gooseff, and Mike Lowe. The purpose of this proposed study was to expand the resources for the core project and permitting a more focused effort on effects of vegetation manipulation on groundwater hydrology. This proposal, while having a lot of support from both political and private interests, was not funded.
- Developed CURI grant proposal to USU entitled: Genetic Variation in Western Aspen (Populus tremuloides): Establishment of an Integrative, Long-Term Research Initiative at USU. This proposed work is designed to provide monies to process and analyze the aspen leaf samples collected during summer 2004 and to provide resources for developing a USDA-NRI cooperative research grant on aspen restoration and genetics. Principals for this proposed work were Karen Mock, Mike Pfrender, and Ron Ryel. The CURI grant was funded and will run for one year.
- Developed ADVANCE grant proposal to USU entitled: Aspen in Western Ecosystems: Landscape-scale Genetic Patterns and Ecological Implications. The proposed work is to develop a collaborative research effort focused on aspen genetics. Principals for this proposed work were Karen Mock, Mike Pfrender, and Ron Ryel. The ADVANCE grant was funded and will run for one year.
- Developed integrated aspen research group. This research group will help coordinate research efforts concerning aspen, including current Cedar Mountain Initiative and Tall Forb research efforts that are being conducted in cooperation with the USFS Rocky Mtn. Research Station in Logan, UT.

Summary of Important Findings to Date

Hydrology. Streamflow data collected in 2004 from Frost Canyon Creek and Bear Canyon Creek, show that timing and magnitude of stream discharge is similar in both catchments (Fig. 1). We have also deployed two meteorological stations, one at the top of Bear Canyon, and the other at the confluence of the two creeks. Air temperature data from these stations shows that in general the bottom of the canyons have a larger diel swing in temperatures than locations at the top of the canyons (Fig. 2). Data acquisition from these instruments has been ongoing throughout 2004 and we continue to refine our water sampling protocol for monitoring stream chemistry and stream water isotopic signatures. Data collected in 2004 was not continuous, but has shown that there are significant differences in stream chemistry, likely due to the differences in watershed geology. Additionally, as soon as weather permits, a portable stream gauge will be deployed higher upstream in frost canyon in an attempt to gain more understanding of the hydrology associated with the geology. Hydrological, water chemistry, and meteorological data acquisition will continue indefinitely.

Soil Biogeochemistry. Preliminary laboratory studies have shown that forest soils produce soil carbon that is both more water-extractable (i.e., leachable) and also more decomposable. This would suggest that increases in water availability (i.e., under an increased summer precipitation scenario) could result in declines in soil organic carbon (SOC) pools, through accelerated decomposition by the microorganisms and leaching. The SOC in rangeland soils, especially under forbs and grasses, appears to be generally more stable, indicated by lower solubility and lower decomposability. This SOC loss would be minimal with a projected increase in precipitation. There also appears to be differences in quality of SOC among forest plant communities.

Similar results were also obtained in the field where CO_2 release rates, used as indicators of microbial decomposition under field conditions, were generally higher from forest than rangeland soils. This is consistent with the prior laboratory observations that showed greater decomposability of SOC in forest soils. Respiration also varied temporally, reflecting differences in microclimate (moisture restriction in summer, temperature restriction in fall).

Plant physiology. Aspen clones populating a common garden at the mouth of Green Canyon near Logan, UT since April, 1978 differed significantly in structural characteristics (DBH), physiology (CO_2 and water vapor gas exchange, leaf water potential) and survival. This strongly suggests that individual clones have very different abilities to perform when exposed to similar ecological and environmental conditions, highlighting the importance of the genetic basis for aspen restoration. Differences in physiology were also found among individuals found in different ecological settings in forest areas at Deseret Ranch and Franklin Basin. Whether these differences had genetic basis, or were related more to the differences in the ecological setting has yet to be determined.

Vegetation surveys. An inventory of the current riparian community vegetation in the Bear Creek and Frost Creek drainages within the study area was conducted. Existing range conditions, percent cover and species composition were observed and measured. All vegetative community types were listed with their percent composition (at least 25%). A threatened, endangered and forest sensitive plant inventory and a noxious weed inventory were conducted along both

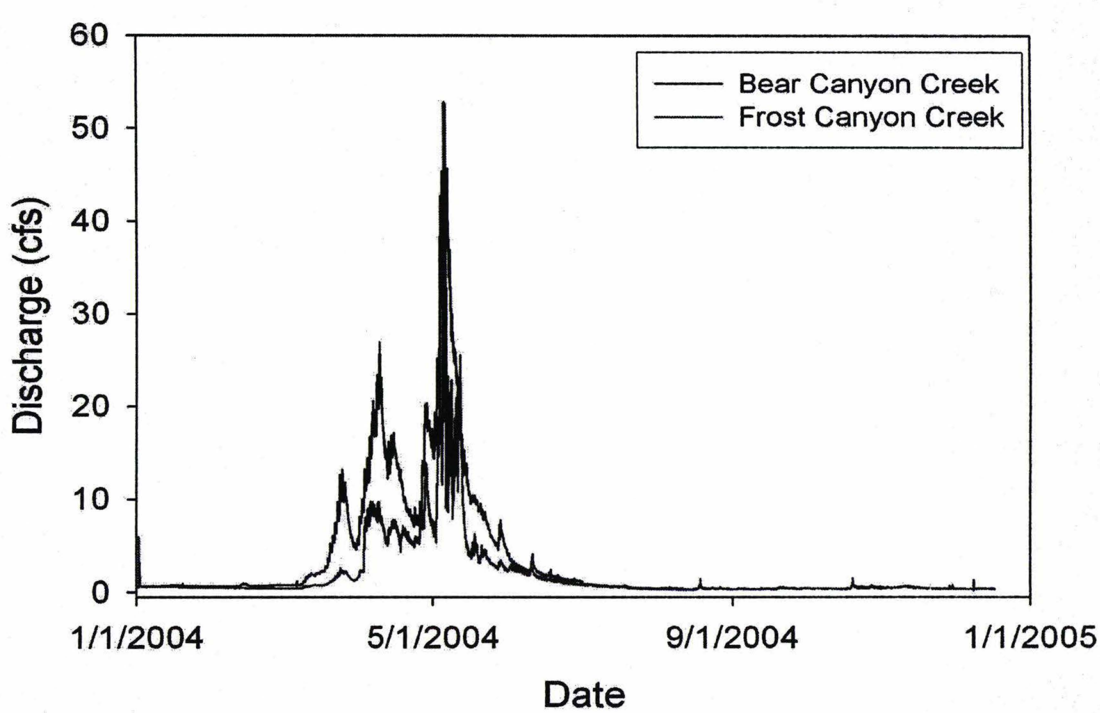

Fig. 1. Stream discharge data for 2004 from both stream gauges.

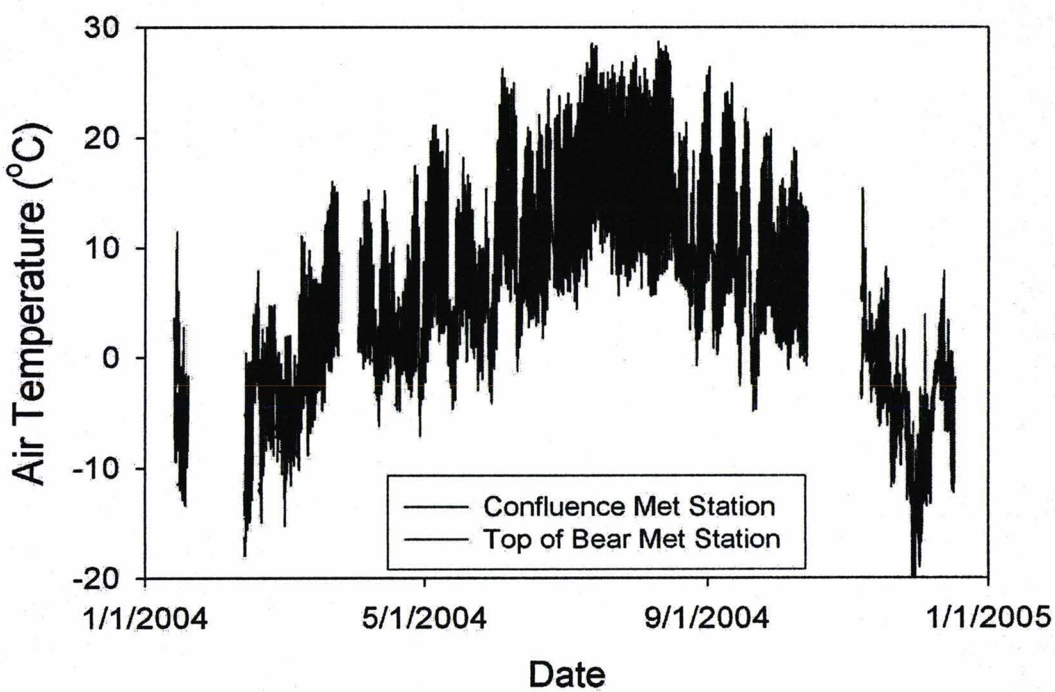

Fig. 2. Air temperature data for 2004 from both meteorological stations.

drainages and along most of the roadways leading into Bear and Frost Creek drainages. Most transects contained populations of Canada thistle (Cirsium arvense). A species check list of species encountered in Frost and Bear Creeks, including habitat, location and associated dominant species assemblages was completed. An initial assessment of condition suggests that the surveyed drainages are recovering from a period of reduced range condition.

Literature Review. Two literature searches were conducted during the first year of the project: 1) on vegetation manipulation as related to water yield and 2) research on aspen. The first search has compiled approximately 200 citations dealing with various aspects of forest vegetation manipulation and effects on resources. The second search has accumulated over 7,000 citations on aspen research. A review focused on the health of aspen communities in Utah, based on this review, has provided a list of important research questions concerning aspen that are pertinent to this research project. These include:

1. What changes in water production occurs when aspen stands convert to conifer dominated sites in the Intermountain West?
2. Should we be concerned with the loss in products (water, forage, wildlife habitat, etc.) with 50-75% decline in aspen dominated sites throughout R1, R2, R3, and R4?
3. Can fuel loading associated with aspen/conifer landscapes be determined using remote-sensed techniques currently being developed?
4. Can intensively monitored sites on the Bridger-Teton N.F. be used in concert with remote-sensed techniques to prioritize aspen/conifer sites for prescribed burning?
5. Can corridors of "pure" aspen be created that would function as naturally occurring fire breaks?
6. Can "pure" aspen be used to protect structures from catastrophic burns at the wildland/urban interface?
7. What are the impacts of fire on various soil properties on aspen/conifer sites?
8. Does burning late successional aspen (conifer dominated sites) effect the success of restoring aspen?
9. Does time of burn effect restoration of aspen?
10. What is the fire history of high elevation forests in southern Utah?
11. Will knowing frequencies of historical fires in help Resource Managers make better management decisions?
12. Do aspen in northern Utah occur predominately in persistent stands or are these stands primarily seral?
13. What are appropriate landscape settings for persistent and seral stands of aspen? Do these differ?
14. What are the effects of prior land management on aspen health?
15. How can aspen be effectively regenerated when clones are lost due to vegetation encroachment?
16. What is necessary for aspen regeneration through seedling establishment?
17. What factors enhance conifer encroachment into aspen stands?
18. How important are the genetics of clones in the success and function of aspen on the landscape?
19. How do aspen or conifer communities alter soil biogeochemistry?
20. Do long-standing aspen clones leave biogeochemical signatures in the soil?
21. What is the age structure of aspen clones on the landscape?

22. How closely related are adjacent aspen clones?